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REGIONAL SPECIALIZATION AND UNIVERSITIES: THE NEW VERSUS THE OLD *

Pontus Braunerhjelm
(The Royal Institute of Technology)

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Corresponding author: pontusb@infra.kth.se

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Regional specialization and universities; The new versus the old

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Pontus Braunerhjelm[†]

Abstract

This paper analyzes the impact universities have on regional development and as to whether a difference can be detected between the influence of the old and new universities. To achieve this end a unique dataset on the researchers' view regarding the universities role in commercialization, distinguishing between new universities (established around 1970) and old universities (established in the 15th and 17th century), is initially utilized. In the subsequent stage spatially disaggregated data is implemented in a two-step Heckman regression analysis to examine whether a relationship exists between the universities research specialization and regional production specialization 1975 to 1999. The results reveal that there are considerable differences across universities, albeit primarily unrelated to the age of the universities. Finally, the impact of universities on regional productivity in knowledge-based industries is examined.

Keywords: Universities, norms, regional development, policies.

JEL: J24; O31; O57

[†] Leif Lundblad's Chair in International Business and Entrepreneurship, The Royal Institute of Technology, Stockholm, SE–100 44 86 Stockholm, Sweden. Phone: +46 8 7909114, fax: +46 8 4117436, e-mail; pontusb@infra.kth..se.

1. Introduction

An increasingly seamless world, driven by globalization and integration efforts, at the country level, has revived an interest in regional development. Moreover, it has sparked a restructuring process with implications for regional production patterns and specialization, where some regions are likely to loose strong economic entities while other will prosper and grow. The regional response to these new challenges has revolved around policies to attract and sustain knowledge intensive production in the higher range of the value-added chain. The outcome of the ongoing structural adjustment process is an open issue, but depends on the flexibility, economically and politically, to adopt measures to build a strong and locally anchored knowledge resource base. Local universities, with a solid national and, preferably, international reputation are a natural and important node in regional restructuring towards a knowledge based economy.

However the mere regional presence of universities does not suffice. To convert academic knowledge into goods and services the university has to be embedded in an environment conducive to commercialization and growth. Thus, the challenge for policy-makers, at the local and national level, is to provide the institutions with an environment that enables academic knowledge to be converted into commercially viable products and services. A successful diffusion of knowledge to the private business sector can expect to be manifest in an expansion of existing knowledge intensive production, and also to help stimulate the emergence of new production and industries within regions.[1]

A large number of European countries have – or are on the verge of – re-organizing their university systems, where responsibilities have been redefined to include a more active role in the commercialization of research. The rationale for this change is the alleged positive experience in the U.S., which goes back to the implementation of the Bay-Dole Act in 1980, when universities obtained the intellectual property rights (IPRs) to their research results.

Still, opinions differ as regards the effect and desirability of introducing a U.S. based system and the extent to which the Bayh-Dole legislation actually propelled commercialization of university research.

To investigate the importance of universities to regional economic development, and their role in prompting knowledge intensive production, the proceeding analysis will follow two parallel traits: Firstly, based on an extensive survey, we present data on university researchers' (sample size 1053) attitudes, and the prevailing norms within universities, with regard to the commercialization of academic research. To examine whether these norms appear to differ between new and old universities, two universities established in the 1960s and 1970s will be compared with two old and well-established universities. Secondly, an econometric analysis investigates whether regional specialization in knowledge-intensive production corresponds to the respective university's specialization in research, and the extent to which labour productivity is influenced by proximity to universities. The analysis contributes with new insights into the impact on regional development between new and old universities, and also the importance of universities being embedded in a suitable environment to generate a positive impact on regional development.

We believe that Sweden stands out as a particularly interesting case as regards the relationship between public research and commercialization, having emphasized the importance of regional cohesion and using universities to strengthen the regional knowledge base, since the 1960s. Moreover, Sweden has been among the world's largest investors in research and development (R&D), relative to GDP, in the last three decades.

The following section presents a brief survey of previous research that is relevant to the issue we address (section 2). The data, the empirical model and the hypotheses are introduced in section 3, while the results are discussed in section 4. Thereafter, section 5 elaborates on measures to alleviate the weaknesses in the links between university research and the regional economies, while the final section 6 concludes.

2. Universities, knowledge diffusion and regional effects; previous research

The importance of academic research for innovation has been established in a number of studies.[2] The extent of and channels through which knowledge is sourced from universities appears to vary with firm and industry characteristics. For instance, Fontana, Genua and Matt (2003) report that firms' absorption capacity (firm size), patent strategies and headquarter proximity are (positively) correlated with the firms' collaboration with public research organizations.[3] Also informal contacts have shown to be important channels for firms to access university research (Meyer-Krahmer and Schmoch 1998, Arundel and Genua 2004). Other studies show that the returns from R&D in large firms, along with the entry of new technology based firms, display a strong covariance with top level university research (Ward and Dranove 1995, Swann and Prevezer 1996).[4]

The traditional link between research and its commercial applications has primarily been through the "open science model", i.e. externalities created and disseminated by public research at universities. However the role of universities has been partly redefined in the last few decades. Besides the traditional tasks of teaching and conducting research, universities are expected to carry out a more active role in the transformation of academic knowledge into economic knowledge. This so called "third mission" of universities implies a major overhaul of the way universities traditionally operate and are organized, especially in Europe.

A change in the European universities' traditional way of operating requires a new set of routines and norms. Individuals tend to be shaped by the economic and social context in which they have been trained and are currently active . The degree of such social imprinting, the intellectual openness and learning capabilities, together with the incentive structure that faces researchers, determines the potential for the establishment of new norms (Manski 2000, Feldman 2000, Berkovitz and Feldman, 2004). According to Owen-Smith and Powell (2001), awareness of potential success and benefits of closer interactions with private business, the extent to which peer environment embrace such changes, and the academic prestige of commercialization, are critical factors for successful adoption of a new norm. If those factors work to encourage increased interaction with commercial sectors, Owen-Smith and Powell conclude that the chances of a smooth transformation towards a new norm is considerably augmented and may well positively influence both basic and applied research.

The standard device proposed to achieve an improved diffusion of knowledge between academic research and the commercial sector centers around the intellectual property rights. More precisely, most European countries have (until recently) had a system where the individual researcher, irrespective of whether public funds were used to finance the research, owns the rights to the results of that research (Rosenberg and Hagén, 2003). That contrasts with the U.S. system, where, since the enforcement of the Bayh-Dole act in 1980, the universities own the right to commercialize results originating from research. By transferring the right to appropriate potential revenues of academic research over to the universities, it has been claimed that the incentives to commercialize and improve the links to the private sector are strengthened.

However, there is an ongoing debate as to whether the institutional change in the U.S. actually prompted the increase in university patenting, or whether that was already taking place due to substantial increases in research funding, especially in biotechnology, in the late 1970s and the early 1980s. Surveying this strand of the literature, Genua and Nesta (2004) conclude that there is no evidence of university owned intellectual property rights (IPRs) being an efficient device to transfer technologies and know-how to the commercial sector.[5]

It has also been questioned whether the lower numbers of patents in Europe could be translated into a lower rate of commercialization. Some studies provide evidence to show that the extent of the commercialization effects of European public research is underestimated. A study on Belgium, Finland, France, Germany and Italy (Balconi, 2003) claims that university initiated patents (although not owned by the universities) are considerably higher. Similar results are reported by Meyer (2003), Sargossi and von Pottelsbergh de la Potterie (2003), and Azagra and Llerena (2003). Still, one would suspect that the same situation prevails in the U.S., i.e. parts of university based research are commercialized through various channels outside the universities. Hence, the view that the impact stretches beyond patents owned by universities is valid. However it is less obvious that this would explain the difference between Europe and the U.S., nor whether the present European system is working satisfactorily.

The link between universities' influence on commercialization, the transformation towards higher knowledge intensity and regional economic development, has also been addressed in previous research. At the national level the role of higher education and skill composition for national growth has been highlighted in a number of studies (Denison 1968, Rosenberg and Nelson 1994, Abramson et al., 1997). More recently this issue has also received an increasing attention at the regional level. For instance, Chesire and Malecki (2004) claim that regional growth is closely associated with the presence of universities and higher education establishments. Similar findings have been presented by Feller (1990), Felsenstein (1996) and Phelps (1998). In particular, the instrumental role of the university in producing localized knowledge has been emphasized (Castells 1989, Bleaney et al 1992, and Mansfield, 1995). The cost of sourcing knowledge seems to be lower the closer to the source, i.e. close to the universities. Thus, distance is indeed a barrier in accessing knowledge diffusion and spillovers (Anselin et al 1997, 2000, Rosenthal and Strange 2003, Henderson 2003).[6]

Several studies also stress that the impact on regional development, in terms of productivity effects and spillovers, is largest for new universities. Examining 14 regions in seven European countries Boucher et al (2003) reached this conclusion. The results are corroborated in an analysis of Swedish data, where a positive association is found over a 14 year period, between growth at the municipal level and the presence of Swedish universities, colleges and technical institutes (Andersson et al 2004). One conclusion drawn by the authors is that the decentralization of universities has spurred regional growth (see also Bleaney et al 1992, Rappaport 1998, Caniels 2000), suggesting that the establishment of new universities is an important ingredient in a strategy to augment regional development.

Other studies focus on the network aspects and the importance of embedding universities in an environment conducive to knowledge diffusion, where entrepreneurship, support functions and the institutional setting are important components (Keane and Allison 1999, Boucher et al 2003). The capacity of regions to absorb new knowledge ("learning regions") and convert that into products is argued to be as crucial, as is the role played by universities and "institutional" thickness (Amin and Thrift 1994, Armstrong 1997, Autio and Yli-Renko 1998, Thanki 1999, Lundvall 1994, Maskell and Tornquist 1999, Karlsson et al 2001). Hence, according to previous research, universities constitute important nodes in regional development and are preponderant in knowledge intensive production (Hotz-Hart, 2000).

3. Data, empirical model and hypotheses

The data base

The analysis will be based on two different data-sets. First, to gain insights regarding the attitudes and norms at the universities towards commercialization we will implement data, initially used in a more general evaluation of Swedish universities, gathered by the Swedish National Audit Office (RRV) over the period January–March 2001. These data were compiled through an Internet based questionnaire, followed by telephone interviews that targeted all researchers at the technical, scientific and medical faculties. Altogether information from

1053 researchers will be utilized in the analysis; 237 are affiliated with Linköping University, 187 with Umeå University, 320 with Lund University and 309 with Uppsala University. Thus, Lund University and Umeå University is somewhat less well represented in the sample.[7]

Of the four Swedish universities included in the analysis, two (Linköping University and Umeå University) were established quite recently (1975 and 1969), whereas Lund University and Uppsala University are the two oldest Swedish universities, founded in 1666 and 1477, respectively. The former universities are approximately the same size in terms of students, about 30 000 students each, while Lund and Uppsala are somewhat bigger. All the universities undertake research in the medical and engineering fields, however, research in the former field is more pronounced in Uppsala and Umeå. Linköping University in particular has a stronger position then the other universities in engineering, whereas research in Lund University is relatively evenly split between the medical and engineering faculties (Table 1). In absolute terms the universities of Lund, Umeå and Uppsala have about the same numbers of full-time equivalent researchers in their medical faculties, approximately 40 percent more then in Linköping. In engineering the research staff at Lund University and Linköping University are considerably larger, compared to the two other universities.

Table 1

The cities where these universities are located differ somewhat in size, stretching from about 90 000 inhabitants in Umeå to 140 000 in Uppsala. Moreover, the environment in which the universities are embedded also differs; all of them have an adjacent science park of which Mjärdevi in Linköping and Ideon in Lund appear to be the most successful. Uppsala University, on the other hand, has a long tradition of cooperating with large pharmaceutical firms, particularly Pharmacia. In the mid-1990s Pharmacia was acquired by Upjohn, a U.S. firm, and basically left Sweden, resulting in a small firm dominated biotechnology/biomedical cluster emerging. The industrial base seems to be least developed in Umeå. Figures 1a and 1b indicate the extent to which the universities are embedded in a commercial environment relating to the fields of Drugs and medicines and Office and computing machinery, measured as the number of employees in those regions compared to the average region.

Based on previous studies referred to above, we expect the recently established universities to be more engaged in commercialization activities as the often centennial traditions within old universities are likely to have nurtured a culture that impedes interaction and collaboration with the commercial sector.

Second, the regional impact of universities will be assessed by implementing data, acquired from Sweden Statistics, that are cross-tabulated on regions and industries. The data cover the period 1975 to 1999 at three-year intervals. Data are sorted by year, region and industries and include all observations, i.e., the entire population. The industries are classified according to the ISIC-system, and are available at the four-digit level for the years 1975 to 1993. For the years 1996 and 1999 only three-digit data on manufacturing is available. The regional unit we will apply in the analysis is 70 labor market regions.

There are also some missing values in the database predominantly due to variables having a zero value for some observations. In other words, if there are no employees in a certain category, no figure is reported. However, the richness of the database and the relatively limited occurrence of missing values, means that the impact on the statistics should be negligible.

Econometric model

The influence of universities will be estimated by regressing the presence of universities on regional specialization for a number of knowledge intensive industries, while controlling for other factors likely to influence regional specialization. Several regions do not host any of the knowledge intensive industries we will investigate, which motivates a censored dependent variable estimation technique. Even though the use of several different techniques can be motivated, we argue that Heckman's two-step procedure (Fomby et al., 1986) is the appropriate method to capture the sequential production decision.[8] The reason being that a region's specialization depends on a firms' decision where to locate or expand their production, having several options to choose between. More precisely, specialization can be seen as taking place in a sequential manner. First, choosing between all regions, firms decide where production (or expansion) should be located. Second, once the regional decision has been taken, production is influenced by a number of regional variables.

The model will be estimated for four separate industries (Drugs and medicines ISIC 3522, Office and computing machinery ISIC 3825, Professional and scientific instruments ISIC 3851, and a "control" industry Metal products ISIC 3813). The dependent variable used in the regressions is a specialization index defined as a region's relative share of employment within an industry. It is defined as employment of knowledge intensive industry *i*, located in region *j* at time *t* (IL_{ijt}), divided by the region's total employment (TL_{jt}) in all industries, compared to the same measure at the aggregate (national) level; $\left(\frac{IL_{ijt}}{TL_{jt}}\right) / \left(\frac{IL_{it}}{TL_t}\right) = RSPEC_{jt}$.

The variable RSPEC is characterized by a large number of zeroes, since there are numerous regions having no knowledge intensive production. The model to estimate is specified as:

$$RSPEC^* = \beta_0 + Z'\beta_1 + \varepsilon_{ijt} \qquad (1)$$

where

$$RSPEC = \begin{cases} RSPEC^* & if \quad RSPEC^* > 0 \\ 0 & if \quad RSPEC^* \leq 0 \end{cases}$$

The residuals are assumed to have the properties $\varepsilon \sim N(0, \sigma_\varepsilon^2)$, $E(\varepsilon_{hjt}\, \varepsilon_{ijt})=0$ for $h \neq i$, $E(\varepsilon_{ijt}\, \varepsilon_{ikt})=0$ for $j \neq k$ but $E(\varepsilon_{ijs}\, \varepsilon_{ijt}) \neq 0$ for $s \neq t$.

The Heckman method implies that initially a probit function is estimated for all observations, i.e., both RSPEC>0 and RSPEC=0 are included in the regressions in order to obtain the probability effects,

$$F^{-1}(Pr(Y)_{ijt}) = J_{ijt} = \alpha_0 + Z'\alpha_1 \qquad (2)$$

where F^{-1} is the inverse of the cumulative standard normal distribution and Y takes the value of one if RSPEC>0, and zero if RSPEC=0. In expression 16, $Pr(Y)_{ijt}$ represents the probability that industry *i* has production in region *j* at time *t*, given the values of the explanatory variables. The α's are parameters showing the influence of the independent variables on the probability that the firm locates production in a certain country. From these estimates, a sample selection correction variable λ - Heckman's lambda - is computed for all observations,

$$\lambda_{ijt} = \frac{f(-J_{ijt})}{1 - F(-J_{ijt})} \qquad (3)$$

where f and F are the density and the cumulative standard normal distribution function, respectively. Then, the sample is restricted to observations for which RSPEC>0, and a standard OLS regression is run, in which the estimated correction variable, λ, is included:

$$RSPEC_{j,t} = \gamma_0 + Z'\gamma_1 + \gamma_2 \tilde{\lambda}_{ijt} + v_{ijt} \qquad (4)$$

The residuals are assumed to have the properties $\nu \sim N(0, \sigma_v^2)$, $E(v_{hjt}\, v_{ijt})=0$ for $h \neq i$, $E(v_{ijt}\, v_{ikt})=0$ for $j \neq k$ but $E(v_{ijs}\, v_{ijt})\neq 0$ for $s \neq t$.[9]

Since Heckman's lambda is included, the OLS equation will yield consistent parameter estimates. However, the estimated standard errors will be inefficient as we use the estimated, rather than the actual, value of λ. A White (1980) correction for heteroscedasticity is therefore required in order to obtain efficient standard errors of the estimated parameters.

At the four-digit level the regressions stretch from 1975 to 1993, while regressions over the full period (1975-1999) can only be implemented using data at the three-digit level. At this level of aggregation the industries are present in most regions, hence, we will also report OLS-estimation results. Finally, we will also regress (using OLS) the presence of universities on regional labour-productivity for the industries mentioned above. In this case data is even further restricted and the analysis will be limited to the period 1996 to 1999.[10]

Hypotheses

Our prime interest concerns the impact of universities on regional specialization. In addition, we would also like to shed light on the commercial environment in which an industry is embedded influences regional specialization. The regions that host the universities we are focusing on – Linköping University, Lund University, Umeå University and Uppsala University - are captured through a dummy variable that is assigned the value of one if a local university exists (UNI-region). The universities differ in their research specialization (Table 1), and we expect these differences to show up in a diversified pattern of regional specialization. In particular, Umeå University and Uppsala University are expected to positively influence regional specialization in the drugs and medicine industry in their respective regions, whereas Linköping University should enhance specialization in the engineering industries, particularly the Office and computing industry. Research at Lund's University is quite evenly distributed between the medicinal and engineering faculties, implying that, á priori, it is difficult to assign any expected impact on regional specialization.

The extent to which an industry is embedded in an environment conducive to production, in that particular industry, should augment a firms' capacity to absorb and convert academic knowledge into commercial products. Data on embeddedness is difficult, if not impossible, to obtain. Here it is approximated by a variable that takes on the value of one if a region hosts one industry at the similar level of aggregation (4-digit level) belonging to the same three-digit industry classification; and a value of two if there is local presence of two industries belonging to the same classification, etc. This variable is denoted as EMBED and proximity to other industry with a similar specialization is expected to have a positive effect on regional specialization.

Turning to the control variables, the two dominant Swedish university regions, i.e. Stockholm and Gothenburg, are included. These two regions each host several universities established between the mid 19th century and the latter half of the 20th century. Hence, they were established in the interim period between the foundation of the two pairs of universities that we have chosen to study. The sheer size and dominance of these two regions (the two largest in Sweden) motivates that they should be controlled for in the regressions, since they are likely to influence the estimations of the other coefficients.[11] The size of these control regions implies that they also have quite a diversified production structure, and therefore the expected influence of universities on regional specialization is more ambiguous.

In the productivity regressions the same variables are used, as in the regional specialization variables. We also add in the average size of firms in the respective industry (SIZE), which is calculated as the number of employees in an industry divided by the number of firms in the industry. It is expected to have a positive correlation with value added, since it should generate internal economies of scale. In addition, it also indicates whether a region's specialization is dependent upon fewer but larger establishments, suggesting that regional specialization is associated with more capital-intensive production. Nevertheless, since we estimate each industry separately, the omission of a capital-variable should not yield biased estimates.

Productivity may also be affected over time through learning and regional spillovers. Data on labour productivity are only available for 1996 and 1999, however, production in previous periods may still influence productivity. To control for this we utilise a variable that takes on a value between 0 and 7 depending on the number of times regions have hosted production (measured by employment) in a particular industry, during previous points of obesrvations (1975, 1978, 1981, 1984, 19987, 1991, 1993). If an industry had no production prior to 1997, the variable attains a value of 0, whereas, had there been production for all of these observations, the variable attains a value of 7. This effect is denoted LEARN and we expect it to be positively related to productivity.

Finally, time specific effects are controlled for by implementing a time dummy (TDUM) that assumes the number one if the year is 1996 and zero if the year is 1999.

The variables are summarized in Table 2.

4. Results

Norms and attitudes at Swedish universities towards commercialization

On a more general basis the survey (RRV 2001) reveals that – according to interviewed researchers - an overwhelming majority of researchers favor a closer interaction with private business. However, this is paired with a seemingly genuine uncertainty as regards the form for such cooperation. More then 50 percent of the interviewees stressed that too much emphasis on cooperation with external agents might constitute a threat to independent research. A similar proportion considers that an increasing part of the research financed by private agents to be negative. The general view among researchers is thus basically positive, but not uncritical.[12]

The extent of the universities involvement in commercialization is reported in Table 3. It is noteworthy that commercialization activities in the older universities (approximately 15 percent in both Lund and Uppsala) is comparable to the level in Linköping (17 percent), whereas a mere 10 percent of the researchers at Umeå University report that they have commercialized their research. Mostly commercialization takes place in corporations where researchers do not have a proprietary interest. According to Table 3, 40 percent of the researchers report that commercialization is not possible, with the exception of Umeå University, where the share is considerably higher (52 percent). Umeå researchers also deviate from their colleagues at the other universities in their opinions regarding the commercial potential of research and the portion that intend to commercialize their research.

Table 3

Table 3 conveys two main messages. First, there appears to be a quite large unexploited stock of research, or ongoing research, that has not been included in the commercialization process. Second, there is also evidence of differences, among the universities, in commercialization activities and attitudes that are not simply related to historical factors.

The positive attitude towards commercialization is further highlighted in Table 4. Between 84 percent (Linköping University) and 71% (Umeå University) agree completely or partially with the view that it should be the responsibility of the university to encourage the commercialization of research results. These figures match the share – albeit covering an earlier period – that has been presented for the U.S. (Link 1996).

Table 4

When it comes to implementing concrete measures, Table 4 reveals that consultancy missions and support for technology-based start-ups, by providing business incubator services, are most favored by the researchers, followed by research contract with private firms. Interestingly enough, up to 50 percent of the Swedish researchers also think that patents should be valued as highly as scientific publications. However, there seems to be more skepticism towards the role of the university as an investor in seed capital.

With regard to active measures the universities take to enhance commercialization, they all have holding companies which were established at the initiative of the Ministry for Industry, Employment and Communications in 1993 with an initial endowment of approximately 700,000 U.S.$. There has been no additional government funding, but they are allowed to expand the capital base through cooperation and joint venture with private companies (Acs and Braunerhjelm, 2005). The holding companies, who started to operate more actively in the latter part of the 1990s, are the core instrument of the universities in support of an improved interaction with the private sector.

How well do the universities' central supporting functions for facilitating the commercialization process work? According to the researchers who have commercialized their research in firms where they have a proprietary interest, a minority think that holding companies work well. However, in three out of four universities around 80 percent of the researchers either do not know what the holding company does, or consider that it has not succeeded in explaining what support it offers (Figure 2). For research that has been commercialized in firms where researchers have no proprietary interest, the share is even higher.

Figure 2

Thus, despite the fact that university support functions have existed for about 10 years, knowledge about their role seems to be very limited among researchers. This must be considered a failure, and there is obviously a huge potential for improvement.

Regional effects of universities; Regression results

Their role in regional development could be expected to partly mirror the production structure in areas where universities are located. First, universities should be instrumental to knowledge intensive industries as a supplier of skilled labor and in access to research facilities, generating externalities in terms of knowledge spillovers and academic entrepreneurship. Second, as discussed in section 2, proximity seems to be important in order to exploit knowledge spillovers.

We ran the regressions on three knowledge industries - Drugs and medicines, Office and computing machinery and Professional and scientific instruments – and a less knowledge intensive "control" industry (Metal products). Starting with the 4-digit level for the period 1975-1993, Table 5a reports a positive and highly significant impact of universities being strong in medical research on the probability of regional specialization in pharmaceutical production. Linköping University, being specialized in a different field of research (engineering), is shown to have no influence on regional specialization. Also embeddedness (EMBED) displays a positive influence on the probability of regional specialization in pharmaceutical industry.

Note that there are obvious differences regarding the regional influence of universities, as shown in the Heckman OLS regressions. The presence of Uppsala University has a robust positive impact on the surrounding region's specialization, while Umeå University is shown to have a negative effect and the influence of Lund University is insignificant. We believe this is related to the embeddedness of the industry, even though it is not evident in the second step of the Heckman regression.

The statistical diagnostics support the choice of model, both with regard to Chi square statistics (high probability that the independent variables are significant) and independence statistics (the probability that the selection regression and the "main regression" are independent from one another). The number of observations where the dependent variable is zero, amounts to 373. We also show, for comparability reasons, the OLS regression results which do deviate considerably from the Heckman estimations in several cases.

In the Computer and Office industry a similar pattern emerges (Table 5B). The probability that regions hosting universities strong in engineering research are also specialized in Computer and Office industry is confirmed as shown by the positive and strongly significant coefficient for Linköping University and Lund University. Again embeddedness is shown to be positively associated with the probability of regional specialization in Office and computing industry. In the second step, the Heckman OLS-regression supports the positive effect of the presence of Linköping University, but not in the case of Lund University. This probably reflects the more diversified research going on in Lund University.

The choice of method does not attain a similar strong support in the case of Office and computing machinery as indicated by the independence statistics, which are not as strongly significant as in the regressions on the Drug and medicine industry. Turning to the OLS does not dramatically change the results; the positive effect of Linköping University remains, whereas Lund University fails to reach significance and Umeå and Uppsala Universities are both shown to have a negative effect on specialization in the Office and computer industry.

In the last knowledge intensive industry considered, i.e. Professional instruments, out of the four universities examined, only Lund fails to reach significance (Table 5c). This industry is closely connected to both the pharmaceutical and the office and computer industries and there is no obvious explanation to why Lund University has no impact. It could possibly be related to differences in specialization between the regions, a considerable part of the Professional instruments industry employs traditional industrial production. In the second step of the Heckman regressions (and in the OLS regressions), the influence of the universities varies from being insignificant (Umeå and Uppsala) to negatively (Linköping) and positively (Lund) significant. One reason for these rather ambiguous results may be the relatively small size of this industry; about 13 000 employees in 1993. The kind of complementarities and spillovers between the pharmaceutical and instrument industries may appear in a rather inadvertent manner. Note also that for this industry, embeddedness is not significant.

Finally, we ran an OLS-regression on the impact of the universities on a less knowledge-intensive industry, Metal products (Table 5d). Linköping University shows the only positive effect; the interpretation being that this University is located in one of the industrial cores of Sweden, and that part of the specialization in industries related to engineering spills over to Metal products.

Considering the entire period, 1975 to 1999, we have to resort to more aggregated data at the three-digit level, which means that most regions will actually host some production of the particular industry. The test statistics reject the two-step Heckman method and therefore OLS-techniques are implemented in the remaining regressions. The results are shown in Table 6. In the pharmaceutical industry the results are very similar to those obtained at the three-digit level; the significant differences being that Umeå University is now shown to have a negative and significant impact, while embeddeness does not display any effect on regional specialization. At this level of aggregation the latter variable becomes quite general and its relevance on the particular industry less obvious. In the Office and computer industry, the resultant sign of Linköping University changes from significantly positive to weakly negative. This suggests that even though positive effects accrue from the university on regional specialization, they appear at a more specialized level captured by the three-digit industry classification. In the instrument industry the results are basically the same for the four universities considered. Finally, in the “control” industry, Metal products, all universities are shown to have a negative and significant effect, indicating that to some extent universities “crowd out” simpler production. The low squared R-values are not too alarming, considering the high values of the F-statistics and that this is a cross-sectional analysis..

The last Table 7 contains the results for the labour productivity regressions, also undertaken at the three-digit level, since data are constrained to 1996 and 1999. In the pharmaceutical industry the negative effect of Umeå University deviates markedly from the other two universities (Lund and Uppsala), with a pronounced specialization in medical research. The learning variable does not attain significance, while size and embeddedness display weak positive productivity effects. The latter signals some type of inter-industry spillovers, and it is also the only industry in which the effects of embeddedness gain some support.

In the Office and computer industry, Linköping University, as expected,is shown to positively affect productivity together with, – and rather surprisingly, - Umeå University; while the other two universities we scrutinised display no such effects. The learning variable is not included as all regions had production in all the time periods. Turning to the Professional instrument industry, all universities specializing in medical research are reported to have positively influenced productivity, which is likely to capture the complementarities between medical research and instruments often used in the pharmaceutical sector. Note that the learning variable is shown to be strongly positive in this industry, being more production oriented than the research oriented pharmaceutical industry, where no such effects were discerned. Also firm size has a significant impact on productivity. For our control industry, Metal products, none of the universities is shown to have a positive impact on productivity, rather the opposite prevails. Instead, size seems to be the dominant factor of higher labour productivity.

Again, the relatively low squared R-values, albeit considerably higher then in the previous regressions, should not be a cause of concern, considering that this is a cross-section analysis. Moreover, the F-statistics are at a highly satisfactorily level. Even though the analysis basically supports the results obtained at a finer level of aggregation, overall the interpretation of the results becomes harder as we insert broader measures of industries.

5. The role of new universities in regional development

Are new universities the appropriate tool to orchestrate a regional transformation towards new and more knowledge intensive industries? The regression analysis proposes that the universities have a potentially important role to play in regional development, perhaps even decisive, but also that a successful re-orientation of the commercial sector hinges on other factors. As shown by the interview results, it is evident that the older universities are involved in commercialization activities to almost the same extent as the new university in Linköping, which seems to be at the forefront when it comes to commercialization, and considerably more then the university in Umeå. Hence, university conventions and norms related to commercialization do not seem to be determined primarily by the age of universities.

Also the environment in which the universities are embedded is crucial for a successful interaction and collaboration with the commercial sector. Linköping Universiyy in particular illustrates this point. It is located in one of the traditional Swedish industrial areas, which over the last few decades have specialized in aerospace, telecommunication and similar high-technology production. This also aplies to Lund University in the southern part of Sweden, where former manufacturing industries such as shipyards, basic food production and textile have been substituted by drugs and medicines, functional food and, to some extent, office and computer machinery production. In the Uppsala region the universities cooperation with the pharmaceutical industry goes a long way back, even though large firms seem to have been replaced by a biomedical/biotechnology small firm dominated cluster. The environment surrounding Umeå University contrasts starkly with that of the other universities; the industrial tradition is weak, production has been orientated towards resource intensive production and the entrepreneurial spirit has, by and large, been absent. Thus, even though the overall institutional set-up is basically identical within the four regions in terms of regulations, taxes, etc., the outcome differs. Irrespective of the fact that research resources are at approximately the same level, the environment in which the universities are embedded seems to influence the extent of commercialization activities.

As regards the universities' measures to engage more actively in the commercialization process, it must be considered a failure that the holding companies continue to market themselves to the researchers, bearing in mind that they have existed for almost ten years. When compared to the Office for Technology Transfers/Management in American universities, the possibility of deepening and extending the contacts with private business seem great (Braunerhjelm et al 2000, Carlsson and Fridh 2002).[13] Partly, this is also likely to reflect the attitudes and norms prevailing in the respective region as regards the interaction between the public research institutes and the private sector.

6. Conclusions

The analysis suggests that a link does exist between a university's research specialization and the respective region's production specialization. However, it also clear that the presence of a university is not, in itself, enough to spur regional commercialization and development. Without the proper environment, benign attitude and norms towards interaction with the private sector, regional restructuring is less likely to appear. This corroborates conclusions drawn in other studies (Feldman 2000).

An interesting result is that the individual researchers themselves are clearly positive towards commercializing their results, with a large portion even stating that they are willing to devote more time to this purpose. These attitudes are similar to those found for U.S. universities. Furthermore, the analysis suggests that attitudes and norms are coloured by the milieu in which the universities are embedded. University researchers, in regions having a tradition of manufacturing production, report a more favorable attitude towards commercialization. Correspondingly, industries in those regions seem better suited to absorb and convert knowledge, originating in research, into economically viable products and services, judging from regional specialization.

It was also shown that the university implemented policies for facilitating commercialization could be considerably improved. The crucial issue concerns the researchers' links with market-based agents, which are organized mainly through centrally administered measures at the universities. It has previously been shown that centralized organizations for external contacts do not work well in the commercialization process, even though they can fulfill complementary tasks (Acs and Braunerhjelm, 2005, Etskowitz et al, 2000).[14] Apparently this appears to be a more urgent matter then the shifting of intellectual property rights to the universities. Apparently about half of the researchers consider that fewer research results would be commercialized if the present system were abolished (RRV 2001).

Obviously, the conditions for increasing commercialization and interaction with industry are not only shaped by the universities, but are rather a combination of policies at the national, regional and university level. To identify the exact channels of knowledge transfers, cross-fertilization and feedbacks between the commercial sector and the universities is beyond the scope of this paper. Most likely there is an interdependency that mutually benefits the universities and the industries. To investigate more deeply into these mechanisms would be an important task for future research.

Table 1. Number of teaching and research staff (full time equivalents) by university and national research subject area

University/ Faculty	Linköping Number	Linköping Percent	Lund Number	Lund Percent	Umeå Number	Umeå Percent	Uppsala Number	Uppsala Percent
Medical	447	22	771	20	727	32	783	24
Engineering	703	35	963	25	133	6	164	5

Source: Statistics Sweden

Table 2. Definitions and expected signs of the explanatory control variables.

Variable	Definition	Expected effect on value added
University region (UNI-region)	Takes on the value of 1 if a regional university exists, otherwise 0.	+
Embeddedness (EMBED)	Takes on a value of 1 if there exists another 4 (3)-digit industry belonging to the same group at the 3(2)-digit level of classification, 2 if two industries exist, etc.	+
Learning (LEARN)	Takes on a value of 1 if the industry existed in the region in a previous period, 2 if the industry existed in the region at two previous observations, etc.	+
Average size (SIZE)	The average size of firms in one industry and region. Calculated as the number of employees divided by the number of firms.	+
Dummy for (TDUM)	Takes on the value of 1 if the observation refers to 1996, otherwise 0.	+/-

Table 3. The extent of commercialization at the universities.

	Linköping		Umeå		Lund		Uppsala	
	No.	%	No.	%	No.	%	No.	%
Commercialization in corporations where the researcher is the sole owner or has a proprietary interest	13	6	6	3	22	7	17	6
Commercialization carried out in corporations where the researcher has no proprietary interest	27	11	12	7	26	8	31	10
Researchers who intend to commercialize	19	8	10	5	23	7	21	7
There is commercial potential, but it is not exploited	86	36	61	33	122	38	115	37
Commercialization is not possible	92	39	98	52	127	40	125	40
Total	***237***	***100***	***187***	***100***	***320***	***100***	***309***	***100***

Source: RRV (2001).

Table 4. The researchers' views on the role of the University in commercialization of research

	Linköping	Umeå	Lund	Uppsala	Sweden
Encouraging commercialization	84 %	71 %	73 %	78 %	73 %
Encouraging researchers to act as consultants	72 %	64 %	71 %	73 %	69 %
Supporting new firms, business incubator services	75 %	64 %	72 %	67 %	66 %
Investing seed capital	41 %	36 %	37 %	47 %	42 %
An equal evaluation of patents and publications	50 %	35 %	47 %	42 %	43 %
Carrying out research financed by private firms	73 %	56 %	69 %	67 %	65 %

Source: RRV (2001).

Table 5a. Regression results for Drugs and medicines. Heckman two-step model and OLS. Dependent variable: Presence of industry in region and regional specialisation.
(Four digit industry level, 1975 – 1993.)

	Heckman Probit Y=existence	Heckman OLS Y=Regional specialisation	OLS Y=Regional specialisation
UNI-	.39	-1.55***	-.49**
Linköping	(.93)	(-2.74)	(-2.32)
UNI-Umeå	5.19***	-1.71***	.30*
	(4.23)	(-2.62)	(1.96)
UNI-Lund	3.34***	-.79	.60
	(2.75)	(-1.21)	(1.62)
UNI-	7.80***	7.72***	9.91***
Uppsala	(5.87)	(3.62)	(5.78)
Gothenburg	1.29	-2.33***	-.93***
	(.99)	(-3.66)	(-2.72)
Stockholm	-2.30	-.04	1.35***
	(-1.26)	(-.07)	(3.64)
EMBED	.85***	.02	.41*
	(2.85)	(.16)	(1.80)
Λ		-1.45	
Constant	-2.18***	2.58***	-.00
	(-7.59)	(3.63)	(-.01)
Wald-Reg		442.71	
P > chi2		.00	
P indep		.00	
R^2			.73
F			58.50
No. of obs.	490	117	117
Left cens.	373	-	-

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Table 5b. Regression results for Office and computing machinery. Heckman two-step model and OLS. Dependent variable: Presence of industry in region and regional specialisation.

(Four digit industry level, 1975 – 1993.)

	Heckman Probit Y=existence	Heckman OLS Y=Regional specialisation	OLS Y=Regional specialisation
UNI-	8.17***	6.85***	6.87***
Linköping	(86.88)	(8.23)	(8.14)
UNI-Umeå	-.86*	-.68***	-.71***
	(-1.76)	(-4.03)	(-4.05)
UNI-Lund	8.41***	.59	.62
	(91.35)	(1.43)	(1.47)
UNI-	-.07	-.56***	-.56***
Uppsala	(-.16)	(3.95)	(-3.94)
Gothenburg	8.83***	-.46**	-.44**
	(79.19)	(-2.26)	(-2.18)
Stockholm	8.68***	1.46***	1.49***
	(87.58)	(8.07)	(8.36)
EMBED	.35***	-.06	-.05
	(4.86)	(-.56)	(-.45)
Λ		-.05	
Constant	-.95***	1.05***	.98**
	(-3.81)	(2.59)	(2.34)
Wald-Reg		679.62	
P > chi2		.00	
P indep		.11	
R^2			.25
F			115.25
No. of obs.	490	302	302
Left cens.	188	-	-

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Table 5c. Regression results for Professional instrument. Heckman two-step model and OLS. Dependent variable: Presence of industry in region and regional specialisation.
(Four digit industry level, 1975 – 1993.)

	Heckman Probit Y=existence	Heckman Y=Regional specialisation	OLS Y=Regional specialisation
UNI-	5.25***	-.60***	-.53***
Linköping	(18.65)	(-6.52)	(-7.15)
UNI-Umeå	5.94***	.41	.48*
	(27.33)	(1.45)	(1.73)
UNI-Lund	.90	.71**	.74**
	(1.01)	(2.49)	(2.60)
UNI-	5.76***	.10	.13
Uppsala	(23.12)	(.45)	(.59)
Gothenburg	-4.04**	-.51***	-.46***
	(-2.50)	(-3.20)	(-2.92)
Stockholm	-13.29***	1.09***	1.12***
	(-4.44)	(3.67)	(3.73)
EMBED	.08	.14	.16
	(.56)	(1.15)	(1.36)
Λ		-.18	
Constant	-.36**	.75***	.67***
	(-2.55)	(8.46)	(10.32)
Wald-Reg		256.04	
P > chi2		.00	
P indep		.09	
R^2			.07
F			35.11
No. of obs.	490	369	369
Left cens.	121	-	-

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Table 5d. Regression results for Metal products. OLS, dependent variable regional specialisation.

(Four digit industry level, 1975 – 1993.)

	OLS Y=Regional specialisation
UNI-Linköping	.49***
	(2.35)
UNI-Umeå	-.76***
	(-14.72)
UNI-Lund	-.48***
	(-5.96)
UNI-Uppsala	-.69***
	(-10.18)
Gothenburg	-.06
	(-1.02)
Stockholm	-.67***
	(-10.71)
EMBED	-.15
	(-1.62)
Constant	1.66***
	(6.23)
R^2	.06
F	51.39
No. of obs.	490

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Table 6. Regression results, OLS.
Drugs and medicines (1), Office and computing machinery (2), Professional instrument (3), and Metal products (4). Dependent variable: Regional specialisation.
(Three digit industry level, 1975 – 1999.)

	(1)	(2)	(3)	(4)
UNI-	-.46***	-.21*	-.46***	-.54***
Linköping	(-3.40)	(-1.69)	(-7.10)	(-5.18)
UNI-Umeå	-.36**	-.66***	.17	-1.03***
	(-2.40)	(-10.45)	(.83)	(-20.56)
UNI-Lund	1.06***	-.34***	1.02***	-.68***
	(6.05)	(-5.55)	(5.93)	(-11.48)
UNI-	3.31***	-1.06***	.74***	-.37**
Uppsala	(5.20)	(-14.49)	(7.18)	(-2.18)
Gothenburg	-.14	-.35***	.50**	-.55***
	(-.87)	(-6.48)	(2.49)	(-9.48)
Stockholm	.99***	-.66***	1.37***	-.97***
	(5.05)	(8.73)	(7.05)	(-15.64)
EMBED	-.17	-.00	.50***	-.31**
	(-1.02)	(-.00)	(7.87)	(-2.19)
Constant	1.41***	1.31**	-1.40***	2.67***
	(2.62)	(2.40)	(-6.53)	(4.73)
R^2	.04	.03	.05	.06
F	58.37	43.65	55.63	77.86
No. of obs.	551	630	554	630

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Table 7. Regression results, OLS.
Drugs and medicines (1), Office and computing machinery (2), Professional instrument (3), and Metal products (4). Dependent variable: Labour productivity.
(Three digit industry level, 1996 – 1999.)

	(1)	(2)	(3)	(4)
UNI-	-.20**	.02**	-.06	-.06***
Linköping	(-2.11)	(2.10)	(-.66)	(-3.65)
UNI-Umeå	-.17***	.10***	.22**	-.01
	(-3.44)	(5.47)	(2.39)	(-.45)
UNI-Lund	.20***	-.10	.13**	-.01
	(4.33)	(-8.59)	(2.53)	(-.69)
UNI-	.33	-.04	.05*	-.02
Uppsala	(.99)	(-.59)	(1.77)	(-1.15)
Gothenburg	-.06	.07***	.13***	-.01
	(-.99)	(5.94)	(3.66)	(-.96)
Stockholm	-.07	.14***	.21***	.06***
	(-1.33)	(5.73)	(7.33)	(6.99)
EMBED	.12*	.01	-.17	.02
	(1.73)	(.57)	(-1.07)	(1.35)
LEARN	.03		.05***	
	(1.18)		(2.90)	
SIZE	.17*	.24**	.45***	.82***
	(1.66)	(2.44)	(4.63)	(5.11)
Tdum	.10*	.02	.03	.03***
	(1.83)	(.90)	(.90)	(2.91)
Constant	-.24	.29***	.46	.18***
	(-.78)	(4.75)	(.75)	(3.00)
R^2	.24	.13	.26	.28
F	19.07	103.59	16.75	31.16
No. of obs.	100	140	96	140

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Figure 1a. Number of persons in respective region employed in the Drugs and medicine industry, 1975 – 1993.

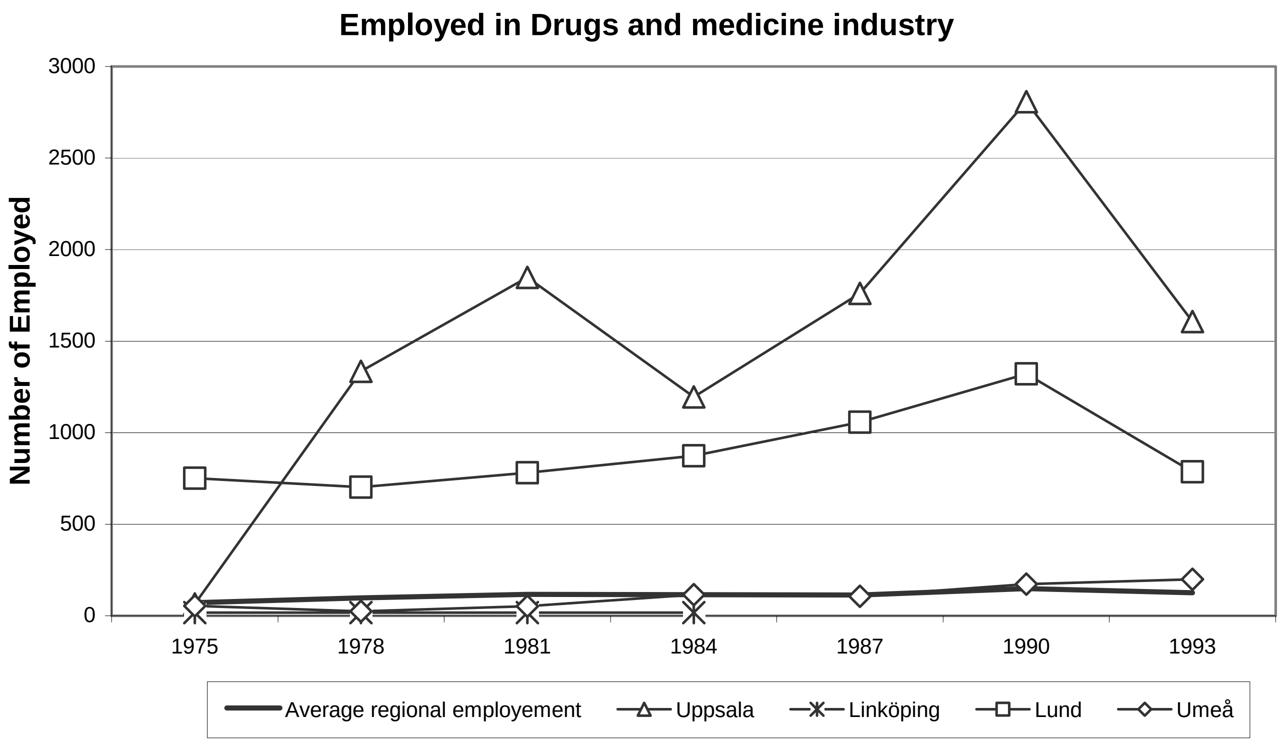


Figure 1b. Number of persons in respective region employed in Office and computing machinery, 1975 – 1993.

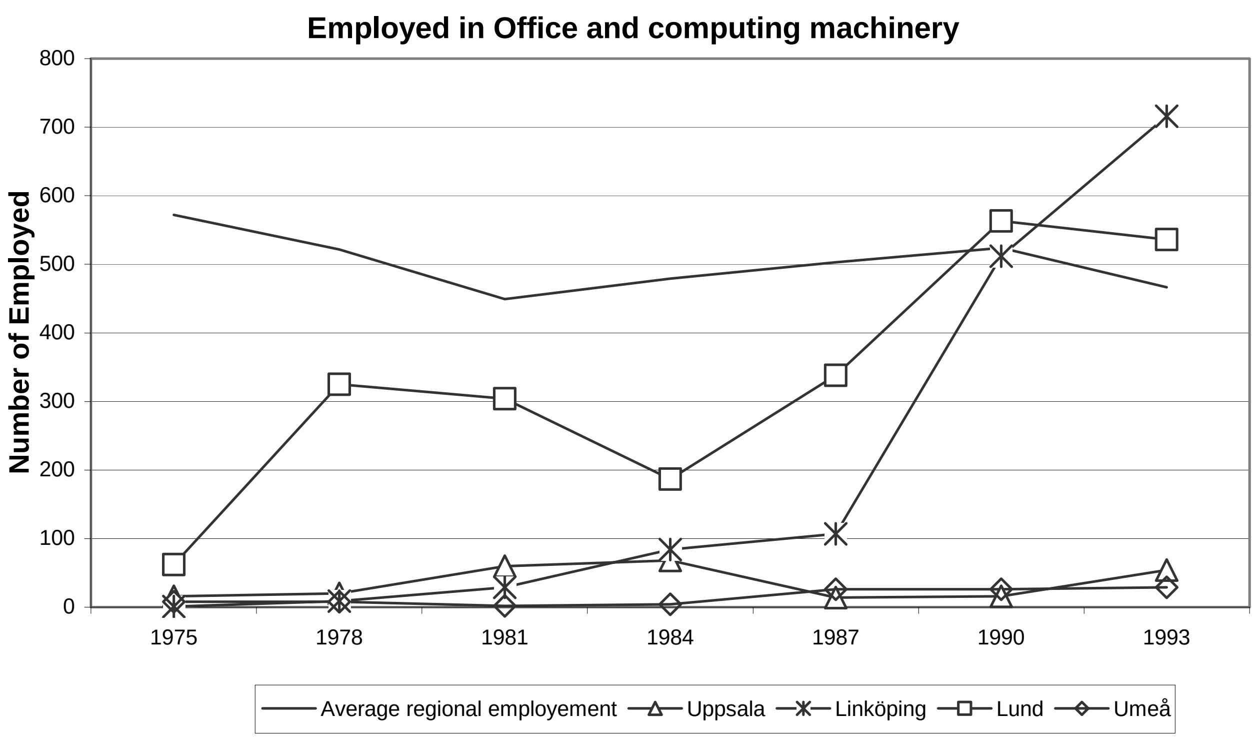
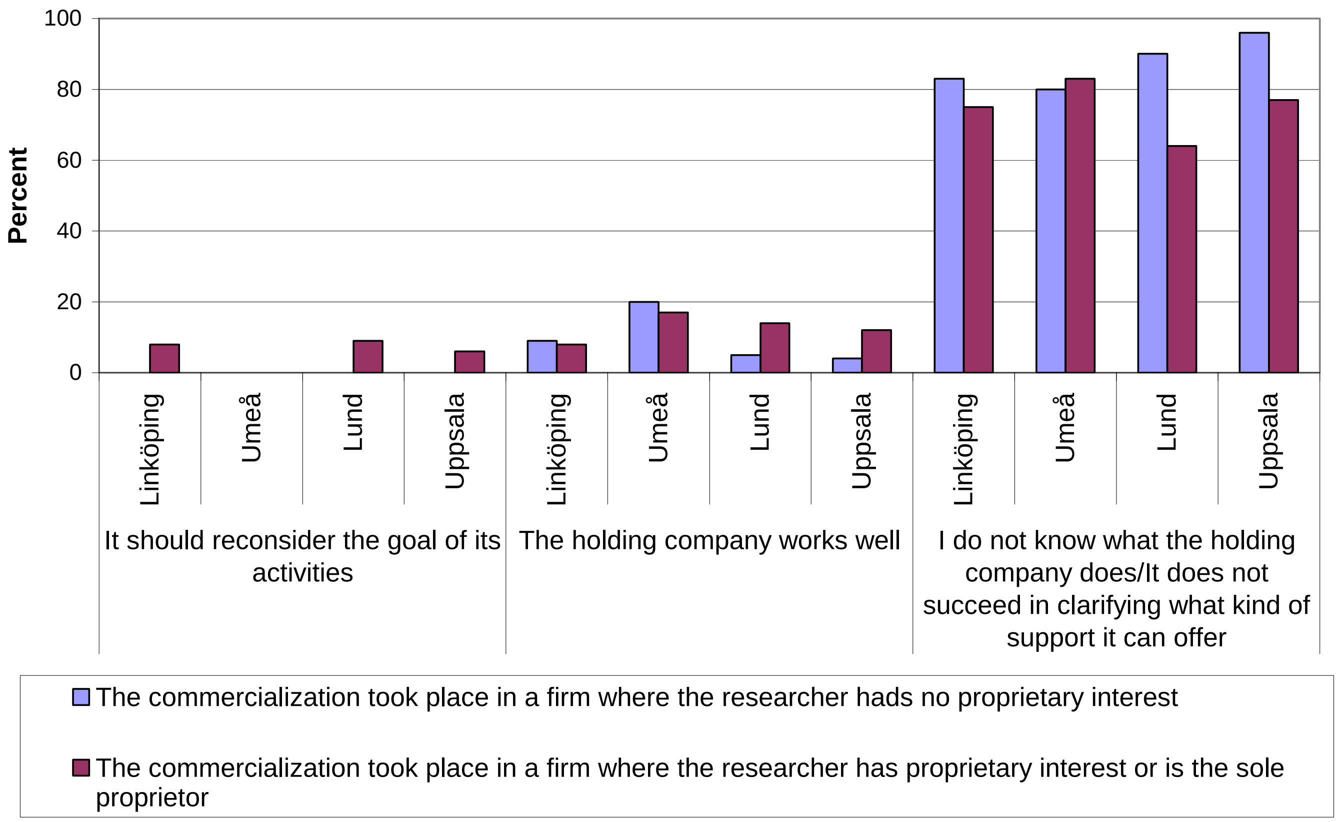


Figure 2. Views of researchers who have commercialized on support from the University holding companies.



Source: RRV (2001).

[1] From a theoretical angle, entrepreneurship linked to universities belongs to the realm of endogenous growth theory, particularly the neo-Schumpeterian approach. In contrast to the neoclassical view of growth – which was based on the supply of capital and labor and an exogenous ”technical residual” – growth is endogenized through the institutions and conditions that governing the production of knowledge by profit-maximizing agents (Romer 1986, 1990,1994, Schmitz 1989, Aghion and Howitt, 1992, 1998, Acs et al, 2003).

[2] Rosenberg and Nelson 1994, Abramson et al 1997, Cohen et al 1998, Beise and Stahl 1999, Caloghirou et al 2001, Miner et al, 2001, Hall et al, 2002

[3] See also Mohnen and Hoareau (2002) and Larsen and Salter (2003).

[44] Moreover the existence of so-called “superstars” seems to be of importance in this respect, as well as personal contacts with strategic agents on the market (Audretsch and Stephan 1996, Zucker and Darby 1996, Allansdottir et al, 2002).

[5] Positive effects are reported by Link 1996, Hall et al 2000, Caloghirou et al 2001 for the U.S., and Norway (Gulbrandsen and Smeby 2002) and Belgium (Ranga 2003) in Europe. Other studies claim that the transfer of IPRs had little to do with the increase in commercialization (Mowery et al 2001, Movery and Sampat 2001, Nelson 2001, and Movery and Ziedonis 2002).

[6] Anselin et al (1997) stress the differences across industries. See Feldman (1999) for a survey of the spillover literature. The role of proximity for innovation is addressed by Kline and Rosenberg (1986), Acs et al (1992), Arundel and Genua (2004).

[7] For a more detailed analysis of Linköping University, see Braunerhjelm et al (2003).

[8] The Tobit method is also a conceivable candidate. However, the estimates reflect both changes in the probability of being above the limit, and changes in the value of the dependent variable if already above the limit. A decomposition of the effects is possible [McDonald and Moffitt (1980)], but the problem is that the two separate effects will always have the same sign and significance. In the present case it may well be that the probability effects and the marginal effects differ. Alternatively, since the location choice of firms is multinomial by nature, one way of accounting for this would be to estimate a multinomial logit or probit. However, the multinomial logit relies on a very strong assumption, the independence of irrelative alternatives, and the multinomial probit involves the evaluation of multiple integrals, something that is not feasible if the choice alternatives exceed three or four. Given these limitations, we believe that the best model to use is Heckman’s two-stage estimation technique

[9] It should be noted that the probit and corrected Heckman OLS equations include the same explanatory variables in vector Z. A possible practical problem is then multicollinearity between Z and λ. There is no theoretical basis that such problems must arise, however, since the latter variable is a *non-linear* combination of Z, while OLS is a *linear* estimation technique.

[10] Standard properties are assumed to prevail with regard to the error term.

[11] The universities in Stockholm and Gothenburg, together with the four universities we are focusing on, comprise the major part of university research in Sweden.

[12] Similar concerns have been expressed for the U.S., i.e. that U.S. universities will leave a highly successful track, characterized by openness, in favor of a more closed system more based on cooperation with the private sector (Merton 1979, Nelson 2001 and Slaughter 2001).

[13] Still, as shown by Movery et al (2001), a technology transfer office cannot be expected to yield considerable increases in university revenue or necessarily result in a substantial increase in patents and licensing. The mission of offices of technology must be seen in a broader perspective, including values within the university, signals to students and the surrounding economic environment (Carlsson and Fridh 2002).

[14] See also Henrekson and Rosenberg (2000).

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